TIME

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- Rocks and the rock cycle
- Plate tectonics
- Volcanoes and volcanism
- Earthquakes
- Time
- Landforms

PREPARED TO MEET SOUTH CAROLINA’S NEW SCIENCE STANDARDS

TIME

- **Relative time** ("chronostratic") -- subdivisions of the Earth's geology in a specific order based upon relative age relationships (most commonly, vertical/stratigraphic position). These subdivisions are given names, most of which can be recognized globally, usually on the basis of fossils.
- **Absolute time** ("chronometric") -- numerical ages in "millions of years" or some other measurement. These are most commonly obtained via radiometric dating methods performed on appropriate rock types.
  - Think of relative time as physical subdivisions of the rock found in the Earth's stratigraphy and absolute time as the measurements taken to determine the actual time that has passed. Absolute time measurements can be used to calibrate the relative time scale, producing an integrated geologic or "geochronologic" time scale.

RELATIVE DATING METHODS

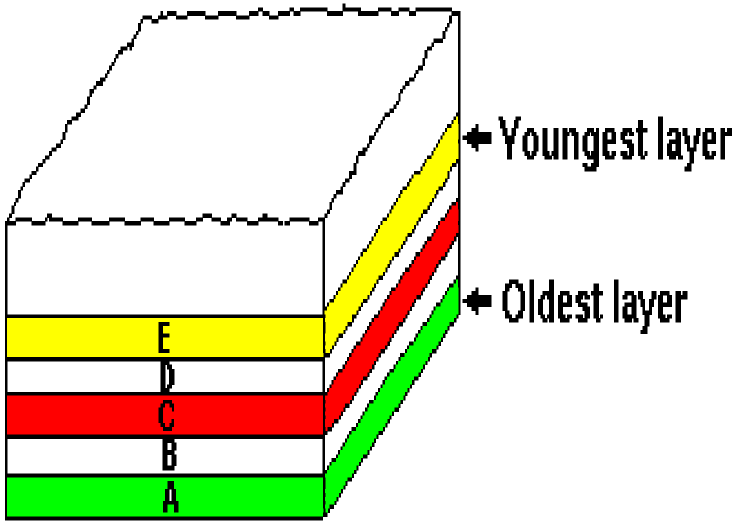
- UNIFORMITARIANISM
- SUPERPOSITION
- ORIGINAL HORIZONTALITY
- LATERAL CONTINUITY
- CROSS-CUTTING RELATIONS
- INCLUSIONS
- CORRELATION

UNIFORMITARIANISM

- Idea by James Hutton in *Theory of the Earth* (1793). The physical, chemical, and biological laws that operate today have operated throughout geologic time. Thus, the forces and processes that we observe presently shaping our planet have been at work since the planet’s creation. "The present is the key to the past.” This important concept can be applied to relative time and absolute time.

SUPERPOSITION

- The **principle of superposition** states that older beds are covered by younger beds, so that in a sedimentary sequence the youngest unit is at the top.



ORIGINAL HORIZONTALITY

- Sediment originally deposited in nearly horizontal layers.

ORIGINAL LATERAL CONTINUITY

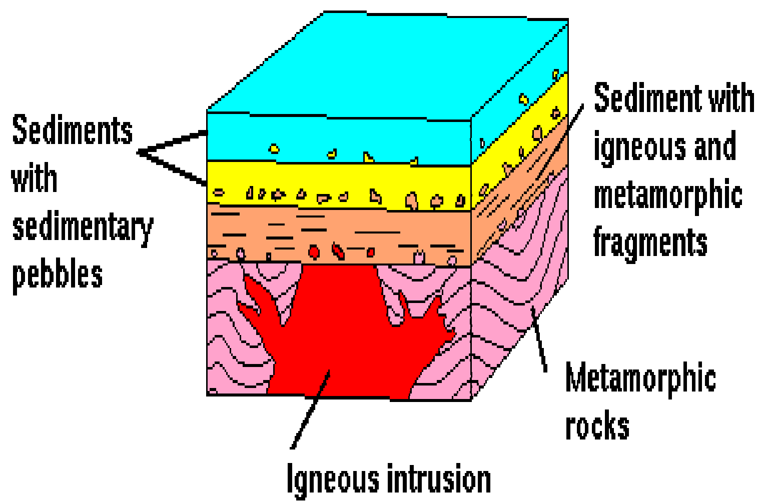
- As originally deposited, strata extend continuously in all directions to the depositional basin edge.

CROSS-CUTTING RELATIONSHIPS

- Cross-cutting rocks such as igneous intrusions are younger than the rocks they cut.

INCLUSIONS

- Any included pebbles and fragments must be older than the host rock containing them.



UNCONFORMITY

- A surface of nondeposition or erosion encompassing significant amounts of geologic time. Recognizing unconformities in the geologic record is important in correlation.

TYPES OF UNCONFORMITIES

- Angular unconformity
- Disconformity
- Nonconformity

ANGULAR UNCONFORMITY

- An unconformity in which the beds below the unconformity dip at a different angle from the beds above it.

DISCONFORMITY

- An unconformity in which the beds above and below are parallel.

NONCONFORMITY

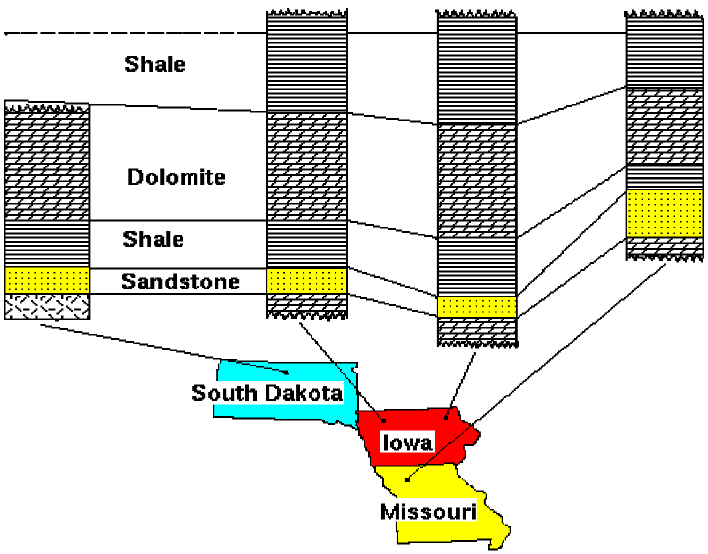
- An unconformity that separates profoundly different rock types, such as sedimentary rocks from metamorphic rocks.

CORRELATION

- The method of using similarities between geologic units to extend information about geologic sequences over large geographic areas.

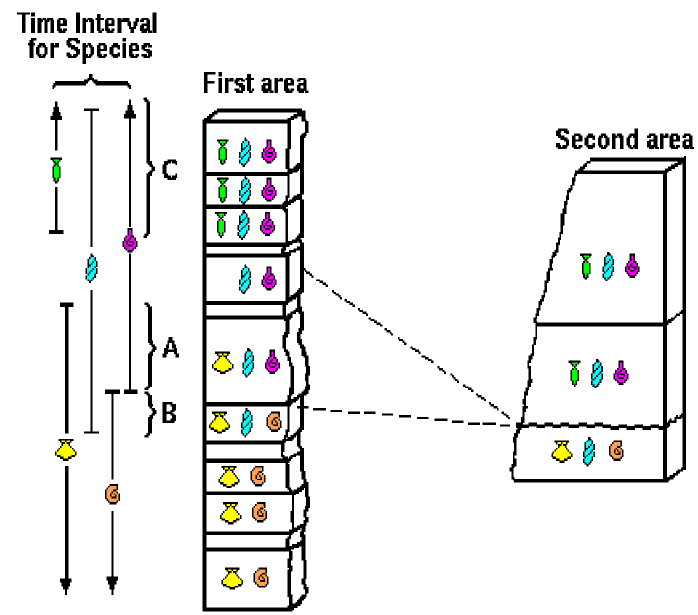
LITHOLOGIC CORRELATION

- In lithologic correlation, a unit is recognized by its lithology (rock type) or a sequence of lithologies. The same distinctive sequence of sandstone (oldest), shale, dolomite, shale (youngest) is recognized over much of the north-central United States.



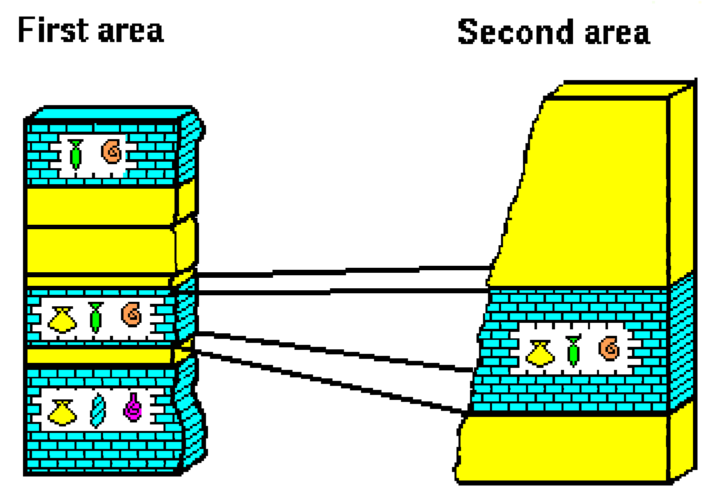
FOSSIL ASSEMBLAGES

- Using fossil assemblages to determine relative ages can result in very precise correlations. Because the A assemblage is missing in the second area, it can be inferred that there is an unconformity between the sequences with assemblages B and C in the second area.



FOSSIL SUCCESSION

- The principle of fossil succession states that organisms evolve through time, and therefore particular forms can be used as age markers wherever they are found. The kinds of animals and plants found as fossils change through time. When we find the same kinds of fossils in rocks from different places, we know that the rocks are the same age.



INDEX FOSSIL

- A short-lived species easily distinguishable from other taxa and known to exist during a specific period of geologic time. They are geographically widespread and independent of rock units.

ABSOLUTE TIME

- Like a clock, absolute dating tells us when a geological event occurred. It provides evidence that the Earth is 4.6 billion years old. Measuring techniques rely on looking at geological processes with a strong annual signature (e.g. growth rings in various organisms) or on processes that occur at a constant and measurable rate (e.g. radioactive decay).

EARLY ATTEMPTS AT DETERMINING THE AGE OF THE EARTH

Biblical methods extrapolating age by using generations listed in Genesis

John Lightfoot (1644)

Bishop Jame Ussher (1665)

Salt concentration in the oceans

John Joly (1899), 90 million years

Rates of deposition

John Phillips (1860), 96 Million years

C.D Walcott (1893), 27.6 Million years

Heat flow from the earth

Lord Kelvin (1862), 20 to 40 million years

ABSOLUTE-DATING TECHNIQUES

Radioactive dating: Radioactive elements decay (fall apart) at steady rates. One "half-life" of time has passed when exactly half of the element remains. Half lives differ from element to element. When they fall apart they form a different material. A ratio between the original material (parent material) and the decay product (daughter material) can be used to determine how many half-lives the material has undergone.

Tree rings- Every year a tree grows a new ring. When the tree dies, the rings can be counted and events such as forest fires can be dated. (Evidence of the same fire may be seen as a layer of ash in the rocks to correlate a rock layer with the tree rings). Tree rings can be used to date events up to 3,000 years ago.

Varves- Layers in sedimentary rock that were formed in a lake. Some lakes have seasonal deposits (ex. sand in the spring from high rain volume and silt deposited in the winter when the top is covered in ice and water flow stops.)

Paleomagnetic dating-A chronometric method that is based on major periodic changes in the Earth's magnetic field. This technique is known by other names--geomagnetic reversal time scale and archaeomagnetic dating.

ABSOLUTE-DATING TECHNIQUES

Fission track -Fission-track dating is one type of radioactive dating method used by archaeologists to determine the thermal age of artifacts containing uranium-bearing minerals. Fission tracks are created at a constant rate throughout time so that from the number of tracks present it is possible to determine the amount of time that has passed since the track accumulation began. Dates anywhere between 20 to 1,000 million years ago (MYA) can be determined with this particular technique.

Racemization of amino acid –A chronometric method that relies on a biochemical clock. It is based on the fact that amino acids (the building blocks of all proteins) exist in two mirror-image forms, both of which otherwise have the same chemical structures. The L-amino acid molecule form has an extension to the left, while the D-amino acid form has an extension to the right. The L-amino acids change to D-amino acids more or less steadily following death--that is, they racemize. As a result, remains of organisms that died long ago will have more D-amino acids than ones that died recently. Aspartic acid (one of the 20 amino acids) is usually extracted from fossil bones or shells for this dating technique.

PARENTS AND DAUGHTERS FOR SOME ISOTOPES COMMONLY USED TO ESTABLISH NUMERIC AGES OF ROCKS

Isotope		Half-life of parent (years)	Useful range (years)
Parent	Daughter		
Carbon 14	Nitrogen 14	5,730	100 - 30,000
Potassium 40	Argon 40	1.3 billion	100,000 - 4.5 billion
Rubidium 87	Strontium 87	47 billion	10 million - 4.5 billion
Uranium 238 Uranium 235	Lead 206 Lead 207	4.5 billion 710 million	10 million - 4.6 billion

THE GEOLOGIC TIME SCALE

Long before geologists had the means to recognize and express time in numbers of years before the present, they developed the geologic time scale. This time scale was developed gradually, mostly in Europe, over the eighteenth and nineteenth centuries The geologic time scale provides a relative measure of time and is based on the fossil record. Fossil species appear and disappear throughout the stratigraphic record. The Geologic Time Scale is based on these appearances and disappearances. Each of the Eras ends with a mass extinction. Period boundaries coincide with smaller extinction events, followed by appearances of new species.

DIVISIONS OF GEOLOGIC TIME

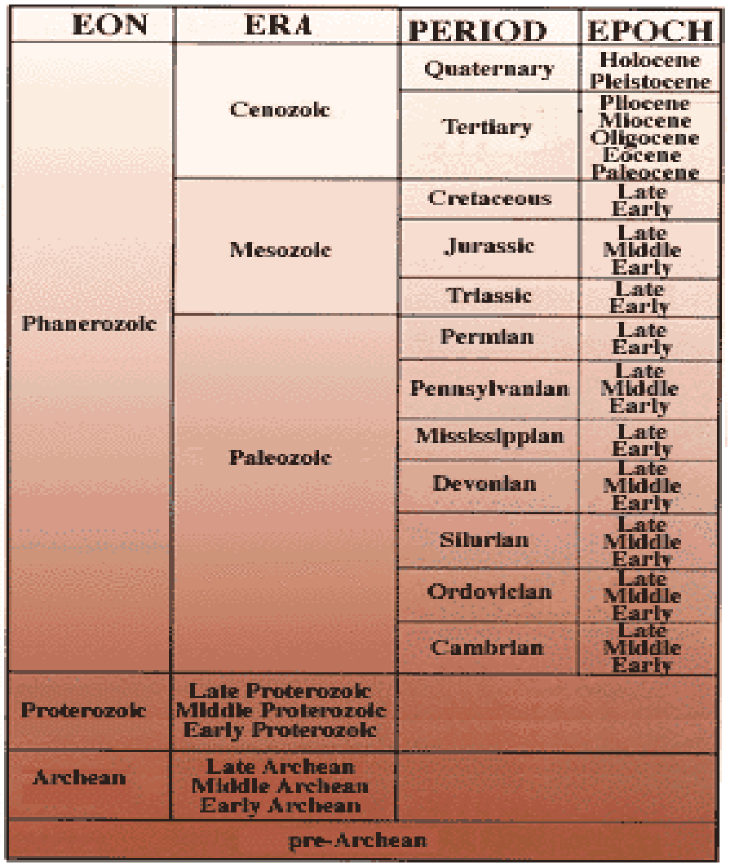
Eons: largest time spans

Eras: subdivision of Eons on the basis of life forms

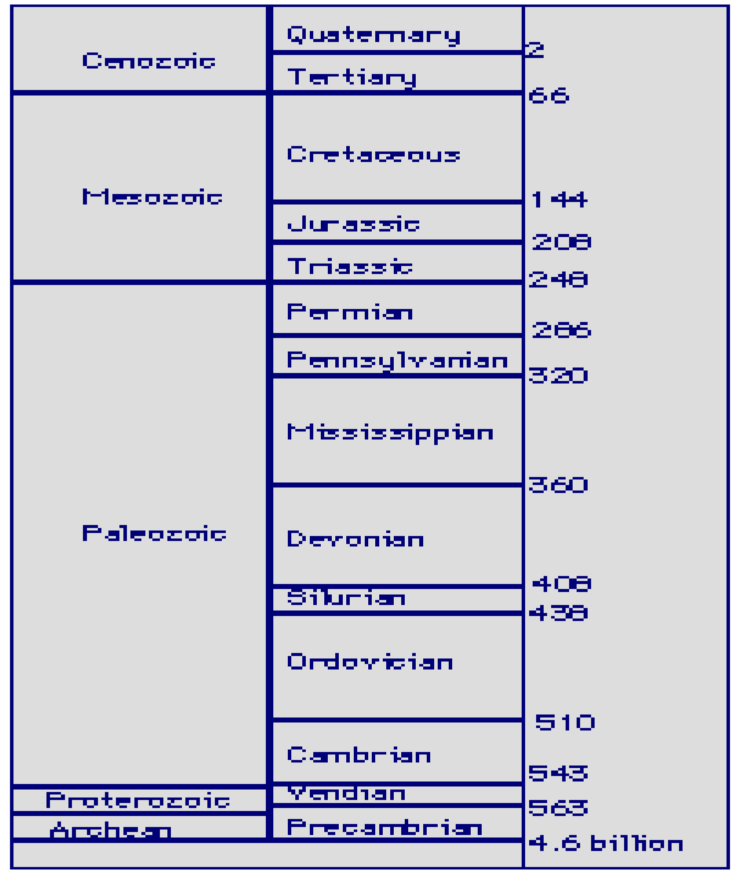
Periods: subdivision of Eras, also based on life forms

Epochs: further subdivision of Periods

THE GEOLOGIC TIME CHART



Relative time

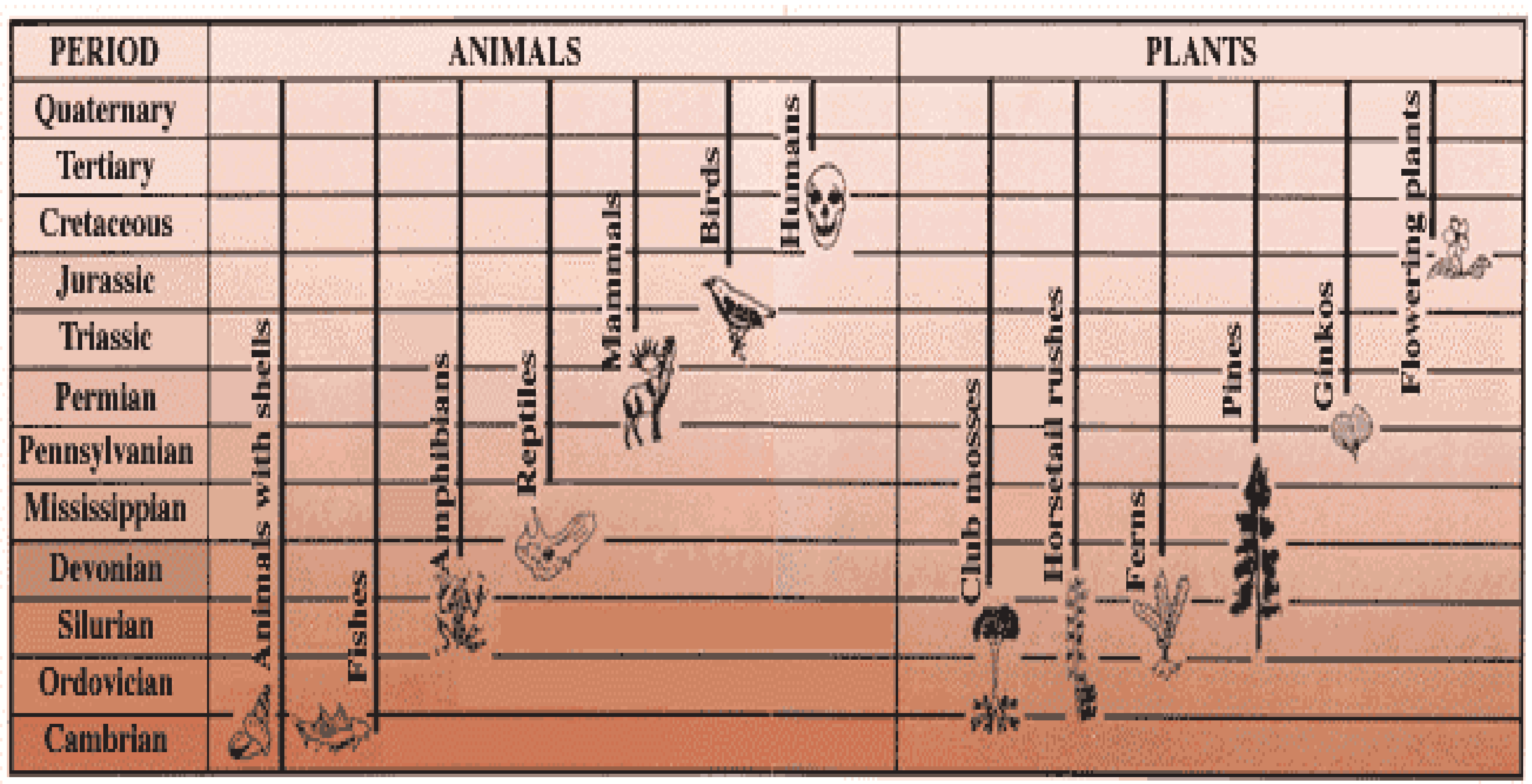


Absolute time

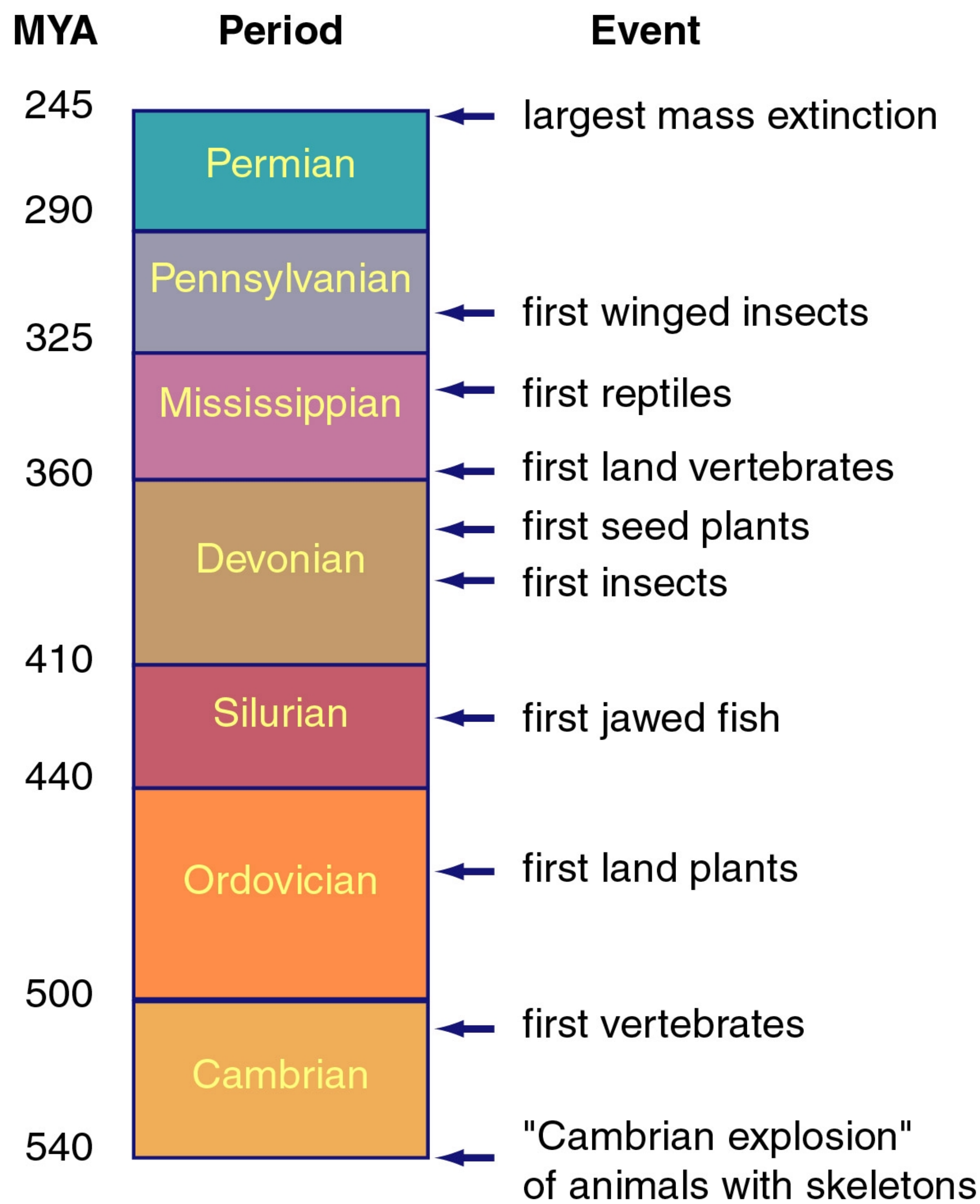
ORIGIN OF GEOLOGIC TIME SCALE NAMES

CENOZOIC ERA (Age of Recent Life)	Quaternary Period	The several geologic eras were originally named Primary, Secondary, Tertiary, and Quaternary. The first two names are no longer used. Tertiary and Quaternary have been retained but used as period designations.
	Tertiary Period	
MESOZOIC ERA (Age of Medieval Life)	Cretaceous Period	Derived from Latin word for chalk (creta) and first applied to extensive deposits that form white cliffs along the English Channel.
	Jurassic Period	Named for the Jura Mountains, located between France and Switzerland, where rocks of this age were first studied.
	Triassic Period	Taken from the word "trias" in recognition of the threefold character of these rocks in Europe.
PALEOZOIC ERA (Age of Ancient Life)	Permian Period	Named after the province of Perm, U.S.S.R., where these rocks were first studied.
	Pennsylvanian Period	Named for the State of Pennsylvania where these rocks have produced much coal.
	Mississippian Period	Named for the Mississippi River Valley where these rocks are well exposed.
	Devonian Period	Named after Devonshire, England, where these rocks were first studied.
	Silurian Period	Named after Celtic tribes, the Silures and the Ordovices, that lived in Wales during the Roman Conquest.
	Ordovician Period	
	Cambrian Period	Taken from the Roman name for Wales (Cambria) where rocks containing the earliest evidence of complex forms of life were first studied.
PRECAMBRIAN		The time between the birth of the planet and the appearance of complex forms of life. More than 80 percent of the Earth's estimated 4-1/2 billion years falls within this era.

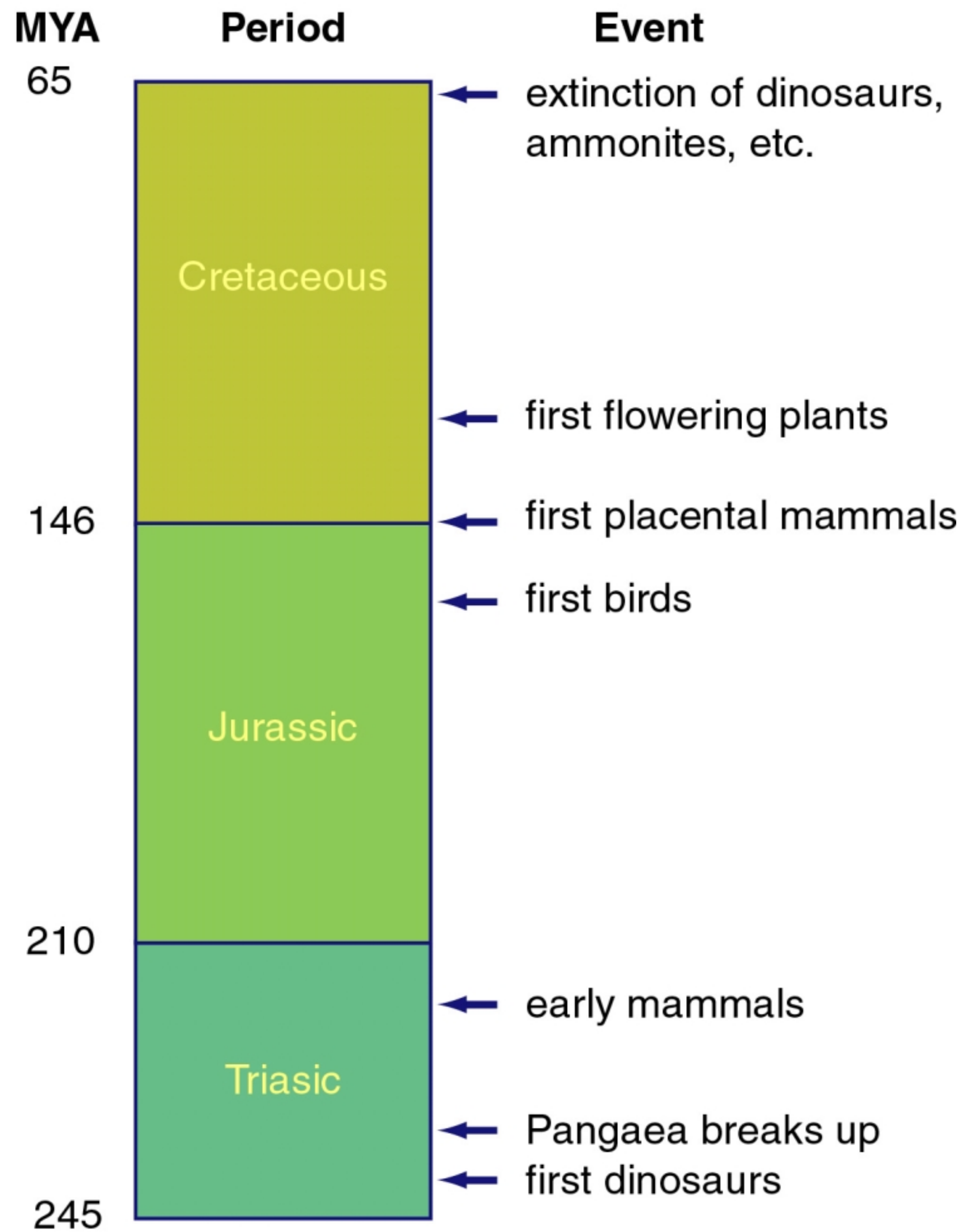
STRATIGRAPHIC RANGES OF SOME MAJOR GROUPS OF ANIMALS AND PLANTS



Paleozoic Events



Mesozoic Events



Cenozoic Events